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GODDARD TECH TRENDS

Goddard Technology Management Office — Goddard Space Flight Center

I'm pleased to welcome you to the debut issue of *Goddard Tech Trends*. The purpose of this quarterly newsletter is to inform you of some recent Goddard technology developments and to describe how they're helping NASA to achieve its mission. I encourage you to pass along this issue to your colleagues and to visit our Web site at **http://gsfctechnology.gsfc.nasa.gov**. There, you can get additional information about Goddard technology as well as an electronic copy of this newsletter.

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Inside:

Where Small Reigns Large

In their quest to build smaller, more capable instruments, Goddard technologists are honing their expertise in Micro-Electro-Mechanical Systems (MEMS) and the emerging field of nanotechnology. Although both deal in the sub-micron world, they are different. MEMS is used to create mechanical devices whose functional features are measured in microns (one-millionth of a meter). Made primarily of silicon, tiny electrical leads, and micro-scale actuators, these devices are found today in automobile airbags, inkjet printer heads,

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1 Making the Case for a Miniature Mass Spectrometer

Technicians work on the Cassini / Huygens Probe.

As work progresses on the first-ever Micro-Elecro-Mechanical (MEMS) microshutter array slated to fly on the James Webb Space Telescope in 2011 (see article 4), the Goddard Detector Development Laboratory has turned its attention to developing another MEMS device — a miniaturized mass spectrometer.

Hasso Niemann, the Goddard scientist who designed and built the mass spectrometer for the Huygens probe, conceived of and is funding the project, said Brian Jamieson, the engineering lead for the project. The program's goal is to build a spectrometer that performs as well as existing spaceflight mass spectrometers, but uses 10 to 100 times less power and weighs 10 to 100 times less.

The first-generation miniature mass spectrometer will be about as large as a pack of gum and consume about as much power as a watch battery. In contrast, the Huygens probe is roughly the size and weight of a bowling ball and consumes as much power as a small light bulb. "While the mass spectrometer on Huygens is an impressive feat of engineering, the Goddard scientists saw in MEMS technology an opportunity to revolutionize the way they designed and built mass spectrometers," Jamieson said.

The Goddard Detector Development Laboratory is using its state-of-the-art MEMS micro-fabrication facilities to design, build, and test the mass spectrometer. Jamieson said his group also is collaborating with the Ames Research Center to develop an electron-impact ion source based on carbon-nanotube emitters. In addition, his group is working on micro-machined alternatives to hand-assembled, electrostatic-lens elements. The goal is to develop miniaturized vacuum components, such as low-leakage micro-valves, that could make system integration easier in the future. Last, Goddard's Microelectronics and Signal Processing Branch has developed the high-speed integrated circuits that will control and analyze the sensor's data, Jamieson said.

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hard-disk drives and pressure sensors. Nanotechnology, on the other hand, involves just handfuls of atoms to create multifunctional materials, devices, and/or systems (see related story below). By definition, a nanometer is one-billionth of a meter, or only about as wide as 10 hydrogen atoms lined up in a row. The field is still developing and could one day produce molecule-sized computer components capable of making calculations at astronomical speeds.

Wide Use for Future Missions

A miniaturized mass spectrometer would find wide use in future NASA missions, Jamieson said. The team envisions a second-generation instrument that mission designers could incorporate into tiny entry probes, which an orbiter could then drop into a planet's atmosphere. This approach would allow scientists to sample and study the atmosphere in multiple locations above the planet's surface instead of in one location.

If equipped with a micro-fluidic device, the instrument also could analyze cometary samples and planetary ices and soils in the liquid phase — science that NASA has never done before. Other uses include monitoring spacecraft cabins and drinking water for contaminants, important applications for the nation's new Vision for Space Exploration.

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Defining Nanotechnology

Goddard is focused on developing a host of strategic nanotechnologies for spaceflight primarily through "spin-in" technologies and prototype developments lead by NASA's research centers and affiliated development partners. "We're an applied nanotech house, not a research and development one," said Dan Powell, who heads Goddard's applied nanotechnology effort. "We're only going to develop technology that can show proof-of-concept in 5 years of the start of development." Other criteria include:

- Materials and systems must have at least one dimension that is no larger than about 1 to 100 nanometers.
- The work must use processes that exercise fundamental control over the physical and chemical attributes of molecular-scale structures.
- Nanotech elements should combine to form larger structures.

2 Sample Nanotube Laminate Produced

Project Moves into Next Phase

A Goddard-lead development effort is expected to demonstrate the first readily scalable process capable of producing samples of a thin-film, oriented carbon-nanotube composite, which technologists believe NASA could use in the development of solar sails, spacesuits, heat and radiation shields, and inflatable lunar habitats or shelters.

Principal Investigator Dan Powell, who leads Goddard's applied nanotechnology research program, said the 3-inch wide material produced in a University of Maryland-College Park laboratory would undergo tests to characterize the sample's strength, thermal and electrical conductivity, and radiation-shielding capabilities.

The project — Oriented Nanocomposite Extrusion (ONE) — began in May 2003 and is funded by Goddard and the Air Force Research Laboratory in Dayton. In fiscal 2005, Powell said the project would branch out to encompass additional investigatory paths that leverage the ONE process development.

Two such follow-on investigations include the Cross-Linked Oriented Nanocomposite Extrusion (CLONE) project, focused on increasing the strength of several low-cost polymers by as much as 75-fold, and the Multifunctional And Radiation Shielding Ionic And Nanostructured (MARShIAN) Composite project, aimed at offering a comprehensive radiation-shielding capability that is both strong and highly conductive. By fiscal 2006, Powell hopes to produce scaled-up samples and ultimately fill the nanotubes with a variety of 'fillers' that tailor the capabilities to an application-specific need. "This is a pretty aggressive investigation," Powell conceded.

Nanotubes — tiny tubes about 10,000 times thinner than a human hair —

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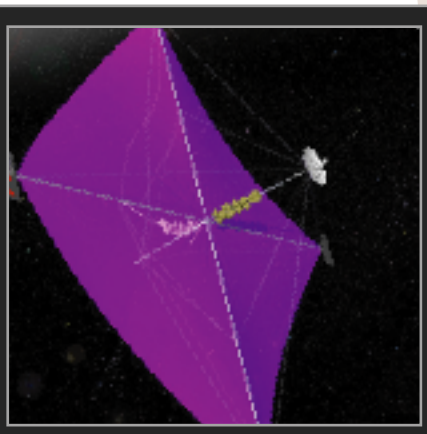

A carbon-nanotube composite may one day be used to develop solar sails.

consist of rolled-up sheets of carbon hexagons. Discovered in 1991 by researchers at NEC, they have the potential for use as minuscule wires or in ultra-small electronic devices and other materials.

In the Goddard development project, carbon nanotubes are oriented in a traditional substrate to enhance the material's strength, electrical, and/or thermal conductivity to meet mission-specific needs. Carbon nanotubes have yet to be applied in a space application, but if the current schedule holds, Powell hopes to demonstrate the first application by 2006 in partnership with the Ames Research Center and the U.S. Naval Academy.

Powell believes that this particular material will ultimately offer a more flexible and multifunctional alternative to graphite-epoxy composites.

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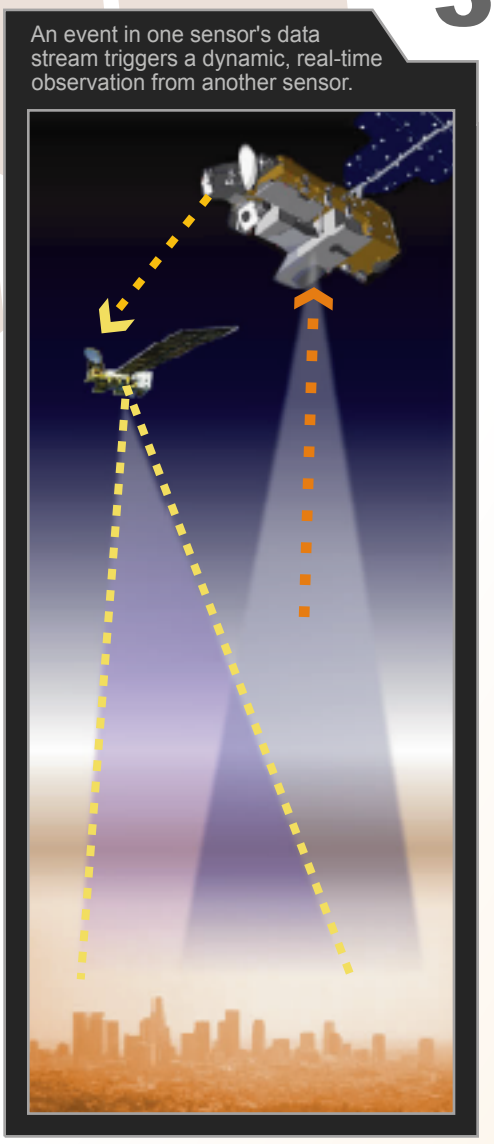
Technologists to Demonstrate Real-Time Sensor Web Technology for Formation-Flying Spacecraft



An event in one sensor's data stream triggers a dynamic, real-time observation from another sensor.

Goddard technologists will begin demonstrating in September the value of sensor web measurement techniques using two Earth Science satellites that fly in formation, including the recently launched Aura spacecraft.

The research involves a number of Goddard organizations and is designed to demonstrate Goddard's leadership in the use of intelligent data collection techniques, said Principal Investigator Stephen Talabac, lead technologist with the Science Data Systems Branch. "Our goal is to demonstrate the benefits of applying dynamic measurement techniques to maximize the return of the most useful scientific measurements."

Unlike current data collection systems, which do not share information across spacecraft, a sensor web operates as a system of systems. It's composed of space, airborne and terrestrial platforms, and predictive computer models similar to those used in weather forecasting. The sensor web combines these elements to form a system that intelligently coordinates data collection and forecast modeling in real- or near-real time.

With a sensor web, scientists and engineers can quickly reconfigure available sensors in response to transient events, perform multi-point, time-synchronous observations of the same event, maximize data collection from the instruments, and reduce errors in forecast models, Talabac added.

During this demonstration, Talabac and his team will each morning identify metropolitan areas that are forecast to have unhealthy air quality and wildfires. Using real-time, direct-readout data from Aqua's Moderate Resolution Imaging Spectroradiometer (MODIS), they will run a very fast algorithm to determine which targets are cloud-free. They will then simulate the targeting of Aura's Tropospheric Emission Spectrometer (TES), a pointable infrared

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spectrometer, to take measurements of only the cloud-free targets. Because Aura is in an orbit that follows Aqua by only 15 minutes, the challenge is to receive and process the MODIS data in real time. "Since Aura and its instrument suite will undergo on-orbit checkout and then routine science operations, we won't have the opportunity to actually command TES. However our research will demonstrate how information technologies and can be applied to implement adaptive observing strategies in the future," Talabac said.

This isn't the first sensor web demonstration. Last year, Goddard investigators set up a sensor web experiment for the NASA Wildfire Response team. When a fire was identified, an innovative Goddard-developed software application called the Science Goal Monitor analyzed Aqua and Terra fire data and automatically coordinated with mission planning systems to schedule imaging from EO-1.

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4 Microshutter Project on Track

These tiny shutters are each the size of a dust mite.

The microshutter array that Goddard's Detector Development Laboratory is developing for the James Webb Space Telescope is on schedule for delivery and integration into the telescope in 2007. NASA hopes to launch the telescope in 2011.

The array is an important enabling technology for the observatory's Near-Infrared Spectrometer. It features hundreds of thousands of microscopic shutters aligned on a silicon grid. Through magnetic actuation and electrostatic latching, these tiny shutters — each the size of a dust mite — open or close to allow or prevent starlight from entering the spectrometer. In this way, astronomers can gather light from only those objects they have selected for study — up to 100 objects per observation.

5 Worth Noting

The following Goddard personnel have received funding from the 2004 Mission and Science Measurement Technology solicitation: **Dan N. Harpold,** Atmospheric Experiment Branch, for the Development of a One-Gram Microvalve for Use on the Next Generation Gas Chromatograph Mass Spectrometer Experiments; and **Pen-Shu Yeh**, Microwave and Communication Systems Branch, for the Ultra-Low Power Radiation Tolerant 32-Bit ColdFire Processor. Yeh also is a co-investigator in the Low-Power Radiation Tolerant Reconfigurable Computing for Spacecraft Instruments and Control (University of Idaho) and Next Generation Radiation Tolerant Design Capability for Deep Submicron (University of Idaho).

The 7th Military and Aerospace Programmable Logic Devices (MAPLD) Conference will be held September 8-10 in Washington, D.C. Contact: Richard Katz in the NASA Office of Logic Design at 301-286-9705 or mapld2004@lkabs.org.

NASA's Sun-Earth Connection and the In-Space Propulsion Technologies Programs Office are sponsoring the **Solar Sail Technology and Applications Conference on September 28-29** at the Greenbelt Marriott, Greenbelt, Md. The conference brings together the technology community and space scientists to discuss recent progress in sail technology and mission concepts. Contact: Tim Van Sant at 301-286-6024.

The **University Research & Engineering Technology Institute is holding a conference October 13-15** at the Greenbelt Marriott in Greenbelt, Md., to discuss developments in nanotechnology. NASA Headquarters is funding the event. Contact: Dan Powell at 301-286-0428.

The **2nd International Symposium on Formation Flying will be held September 14-15** in Washington, D.C. Contact: Jesse Leitner at 301-286-2630 or formationflying@vtext.com.